Journal of the Society of Arts.

FRIDAY, APRIL 29, 1859.

EXHIBITION OF INVENTIONS.

The Exhibition was opened on Monday, the 25th inst., and will remain open every day until further notice, from 10 a.m. to 4 p.m., and is free to members and their friends. Members by ticket, or by written order, bearing their signature, may admit any number of persons. Members of Institutions in Union with the Society are admitted on showing their cards of membership.

CONVERSAZIONI.

The Council have arranged for two Conversazioni during the present Session; the first, on Saturday, the 7th May, at the Society's House, the card for which will admit the Member only; the second, on Saturday, the 28th May, at the South Kensington Museum, the card for which will admit the Member and two ladies, or one gentleman. Cards for each of these evenings have been issued. Members who have not received them are requested to communicate with the Secretary of the Society of Arts.

Members of Institutions who are anxious to attend either of these Conversazioni, are requested to apply to the Secretary of the Society of Arts, through the Secretary of the Institution to which they belong.

EXAMINATION PRIZE FUND, 1859.

The following are the Donations up to the present date :—

	£	s.
John Ball, Examiner in Book-keeping (2nd donation)	5	5
Harry Chester, Vice-Pres. (2nd donation)	5	0
C. Wentworth Dilke, Vice-Pres., Chairman of Council (4th donation)	10	10
T. Dixon	1	1
Frederick Edwards (annual)	1	1
J. G. Frith, Mem. of Council (2nd donation)	5	5
F. Seymour Haden (annual)	2	2
W. Haldimand	10	10
Edward Highton (annual)	2	2
James Holmes (annual)	1	1
Henry Johnson (2nd donation)	25	0
London Committee of the Oxford Middle Class Examinations	5	5
Charles Ratcliff (annual)	10	10
Dr. Skey	1	1
Rev. Dr. Temple	6	6
A Teacher	5	0
Matthew Uzielli	50	0
Rev. A. Wilson	2	2

TWENTIETH ORDINARY MEETING.

Wednesday, April 27, 1859.

The Twentieth Ordinary Meeting of the One Hundred and Fifth Session was held on Wednesday, the 27th inst., Robert Hunt, Esq., F.R.S., in the chair.

The following candidates were balloted for and duly elected members of the Society :—

Corderoy, Edward	Shaw, Thomas
Foster, William	Werry, F. A. W.
Griffiths, Robert	Whitehouse, E. O. Wildman
Jarrett, Griffith	Wilson, Richard
Marshall, Samuel	

The following Institutions have been taken into Union since the last announcement :—

Skipton, Mechanics' Institution.
Wallingford, Mechanics' Institution.

The Paper read was—

ON THE METALLURGY OF LEAD.

By John Arthur Phillips.

Although lead forms an essential element in a large number of minerals, the ores of this metal are, strictly speaking, far from numerous. Of these the most important is sulphide of lead, or galena. This mineral, which possesses a metallic brilliancy, and has a lighter colour than metallic lead, presents, in its cleavage, all the variations, from large facettes and laminæ indicating a cubic crystallisation to a most minutely granular structure. It is extremely brittle, and its powder presents a brilliant, blackish-grey appearance.

The specific gravity of galena is 7·5 to 7·8, and its composition, when absolutely pure, is :—

Lead	86·55
Sulphur	13·45
	100·00

Galena is, however, but seldom found chemically pure, as, in addition to variable quantities of earthy impurities, it almost always contains a certain amount of silver. It is usually observed that galena presenting large facettes is less argentiferous than those varieties having a closer grain, and thus finely granular steely specimens generally afford the largest amount of silver.

It would appear, from recent experiments, that the silver contained in the finely-granular varieties of galena often occurs in the form of sulphide of silver, mechanically intermixed, whilst in the more flakey descriptions of this ore, the sulphides of lead and silver are chemically combined.

Galena occurs in beds and veins, in granite, gneiss, clay-slate, limestone, and sandstone rocks.

In Spain it is found in the granite hills of Linares and elsewhere, at Frieberg in Saxony, it occupies veins in gneiss, in the Harz, Bohemia, Cornwall, and many other localities, it is found in killas, or clay-slate. The rich deposits of Derbyshire, Cumberland, and the northern districts of England are in the mountain limestone, whilst at Commern, near Aix-la-Chapelle, large quantities of this ore are found disseminated in the Bunter sandstone.

This mineral is frequently associated with blend, iron and copper pyrites, the carbonate and other ores of lead, and usually occurs in a gangue of sulphate of baryta, calc-spar, spathose iron, or quartz. It is also not unfrequently associated with fluor-spar.

The next most important ore of lead is the carbonate, which is a brittle mineral, of a white or greyish-white

colour, having a specific gravity varying from 6·46 to 6·50. Its composition is,—

Carbonic acid	16·05
Oxide of lead	83·56
	99·61

Large quantities of this substance occur in the mines of the Mississippi Valley, in the United States of America, where they were formerly thrown away as useless, but have since been collected and smelted. Vast deposits of this substance have also been found in the Bunter sandstone, near Düren, in Prussia, and at Freyung, in Bavaria. In the two latter localities it appears to form the cement holding together the granules of quartz, of which the sandstone principally consists. These ores, which yield from 14 to 20 per cent. of metal, do not readily admit of being concentrated by washing.

The sulphate of lead does not often occur in sufficient quantities to be employed as an ore of that metal. In appearance it is not unlike the carbonate, but may readily be distinguished from it by its not dissolving with effervescence in nitric acid.

Its specific gravity is from 6·25 to 6.30, and its composition—

Sulphuric acid	25·65
Oxide of lead	74·05
	99·70

This ore of lead usually results from the oxidation of galena. At St. Martin's, near the Vega de Ribaddeo, in Spain, this mineral, more or less mixed with the phosphate of lead, is found in sufficient quantities to be made, on a small scale, the subject of an especial metallurgic treatment. Large quantities of sulphate of lead ores are also annually imported into this country from the mines in Australia. These ores contain on an average 35 per cent. of lead and 35oz. of silver to the ton of ore, together with a little gold.

Phosphate of lead, when crystallised, usually presents the appearance of hexagonal prisms, of a bright-green, brown, or yellowish colour. Its specific gravity varies from 6·5 to 7·1. This mineral is composed of a mixture of true phosphate of lead, phosphate of lime, chloride of lead, and fluoride of calcium, and usually contains about 78 per cent. of oxide of lead. In Spain, it occurs in botryoidal forms, in connexion with the sulphate of the same metal, and is treated in blast furnaces for the lead it affords.

The other minerals containing lead seldom occur in sufficient quantities to be of much importance to the smelter, and may therefore be disregarded in the present paper.

The extraction and mechanical preparation of ores is the business of the miner, and not of the metallurgist, who receives the ores from the former freed as perfectly as possible from foreign matters.

The metallurgic processes, by the aid of which lead is obtained from galena, may be divided into two classes. The first of these is founded on the following reactions:—If one equivalent of sulphide of lead and two equivalents of the oxide of the same metal are fused together, the result is three equivalents of metallic lead and one equivalent of sulphurous acid, which is evolved.

This reaction is represented by the following equation:

$$PbS + 2PbO = 3Pb + SO^2.$$

When, on the other hand, one equivalent of sulphide of lead and one equivalent of sulphate of lead are similarly treated, two equivalents of lead are obtained, and two equivalents of sulphurous acid gas evolved. Thus,

$$PbS + PbO, SO^3 = 2Pb + 2SO^2.$$

The process, founded on the foregoing reactions, and which we will distinguish as the *method by double de composition*, consists in roasting the galena in a reverberatory furnace until a certain amount of oxide and sulphate has been formed, and subsequently, after having intimately mixed the charge, and closed the doors of the furnace, causing the whole to enter into a state of fusion.

During this second stage of the operation, the reaction between the sulphides, sulphates, and oxides takes place, and metallic lead is eliminated. The roasting of the ore is, in some cases, conducted in the same furnace in which the fusion is effected, whilst in others two separate furnaces are employed.

The process by double decomposition is best adapted for the richer varieties of ore, and such as are least contaminated by siliceous or earthy impurities, and is consequently that which is almost universally employed for smelting the ores of this country.

By the second method which we will call the *process by affinity*, the ore is fused with a mixture of metallic iron, which by combining with the sulphur, liberates the metallic lead. This reaction will be understood by reference to the following formula:—

$$PbS + Fe = Pb + FeS.$$

In practice, however, metallic iron is not always employed for this purpose; cast-iron is also frequently used, and in some instances the ores of iron and hammer slags are substituted, as are also tap-cinder and other secondary products containing a considerable per centage of this metal. None of these substances are, however, found to be so efficacious as metallic iron, since cast-iron requires to be decarburised before it can readily decompose the sulphide of lead, and the ores of iron require the introduction of various fluxes, and the consequent expenditure of an additional amount of fuel. In all cases, however, it is judicious to subject the ore to a preliminary roasting, in order to eliminate a portion of the sulphur, and thereby reduce the expenditure of iron, as well as to agglutinate the ore and render it better adapted for its subsequent treatment in the blast furnace.

I will not attempt to describe the different forms given to roasting furnaces employed for the ores treated by this process, but would remark that they frequently resemble the kilns used for the preparation of lime, whilst in some instances the ores are roasted in heaps interstratified with wood or other fuel.

The method of treating ore by *affinity* is particularly adapted to those varieties that contain a considerable amount of silica, since such minerals, if treated by double decomposition, would, by the formation of oxide of lead, give rise to silicates, from which it would be exceedingly difficult to extract the metal.

English Process.—Treatment by Double Decomposition.—Galena, if placed in a close vessel which protects it from the action of the air, and exposed to a gradually increasing temperature, becomes fused without the elimination of any lead taking place, but ultimately a portion of the sulphur is driven off, and a subsulphide is formed, which at a very elevated temperature is volatilised without change.

If, however, the vessel be uncovered, and the air allowed to act on its contents, oxygen combines with the sulphur, sulphurous acid is evolved, and the desulphuration of the mineral is slowly effected.

When galena is spread on the hearth of a reverberatory furnace, and is so placed as to present the largest possible amount of surface to oxidising influences, it will be found that the surface slowly becomes covered with a yellowish-white crust of sulphate of lead. The oxygen of the air, by combining with the two elementary bodies of which galena is composed, will evidently produce this effect. This is not, however, the only chemical change which takes place in the charge under these circumstances; oxide of lead is produced at the same time as the sulphate, or rather the formation of the oxide is prior to that of the sulphate.

In fact, during the first stage of the operation of roasting, sulphurous acid is evolved, the sulphur quits the lead, and a portion of that metal remains

in a free state. This becomes oxidised by the air passing through the furnace, and subsequently a part of it combines with sulphuric acid, formed by the oxidation of sulphurous acid, and sulphate of lead is the result. In this way, after the expiration of a certain period, both oxide and sulphate of lead are present in the furnace.

During the early period of the roasting, when the temperature of the furnace is not very elevated, the proportion of sulphate is larger than that of the oxide formed, but in proportion as the heat of the apparatus increases, the production of oxide becomes more considerable, whilst that of the sulphate diminishes.

The sulphate and oxide thus formed re-act in their turn on the undecomposed galena, whilst a portion of the latter, by combining with the sulphide of lead, gives rise to the formation of oxysulphides.

This last compound has no action on galena, except to dissolve it in certain proportions, but is readily decomposed by the aid of carbonaceous matters.

It is therefore evident that the addition of carbon, at this stage of the operation, will have the effect of reducing the oxide and oxysulphide of lead.

Every process then that has for its object the reduction of lead ores by double decomposition, comprises two principal operations. 1st. The reduction of galena, by the aid of heat and atmospheric air, to a mixture of sulphide, oxide, and sulphate, which mutually decompose each other with the elimination of metallic lead. 2nd. The reduction of the oxysulphide by the addition of carbonaceous matter.

The Reverberatory Furnace.—The reverberatory furnace employed for the treatment of galena is composed, like all other furnaces of this description, of three distinct parts, the fire-place, the hearth, and the chimney.

The hearth has to a certain extent the form of a funnel, of which the lowest point is on the front side of the furnace immediately below the middle door. The molten metal descending from every side along the inclined bottom or sole, is collected in this receptacle, and is ultimately run off by means of a proper tap-hole. This tap-hole is, during the operation, closed by a pellet of clay.

The inclination of the hearth is more rapid in the vicinity of the fire-bridge than towards the chimney, in order that the liquid metal may not be too long exposed to the oxidising and volatilising influences of a current of strongly-heated air.

The dimensions given to these furnaces, as well as the weight of the charge operated on at one time, vary considerably in different localities, but in the north of England the following measurements are usually employed: The fire grate is 5ft. 9in. × 1ft. 10in., and the thickness of the fire-bridge 1ft. 6in.; the length of the sole is 9ft., and its average width 7ft. The depth of the tap is about 2ft. 6in. below the top of the inclined sole. The height of the roof at the fire-end may be 1ft. 4in., and at the other extremity 11 inches.

The introduction of the charge is in some cases effected by the doors of the furnace, whilst in other instances a hopper, placed over the centre of the arch, is made use of.

On the two sides of the furnace are placed three doors about 11in. × 9in., which are distinguished as 1, 2 and 3, counting from the fire-bridge end. The three doors on the one side are known as the front-doors, whilst those on the other side are called the back-doors. Immediately beneath the door on the front side of the furnace is situated the iron pan into which the molten lead is tapped off.

The bottom of this arrangement is in most cases composed of fire-bricks, covered by a layer of vitrified slags, of greater or less thickness. In order to form this bottom, the slags are introduced into the furnace, the doors closed, and the damper raised. An elevated temperature is thus quickly obtained, and as soon as the scoriæ have become sufficiently fused, they are, by means of rakes and paddles, made to assume the required form. The charge employed, as before stated, varies in almost every establishment. In the North, however, smaller charges are used than most other localities. At Newcastle, and in the neighbourhood, the charge varies from 12 to 14 cwt.; in Wales, and near Bristol, 21 cwt. charges are treated; whilst in Cornwall, charges of 30 cwt. are not unfrequently worked. The time required for smelting a charge varies with its weight and the nature of the ores, from 6 to 24 hours.

In some cases the ore is introduced raw into the furnace, whilst in others it undergoes a preliminary roasting previous to its introduction. Rich ores are generally smelted without being first calcined, but the poorer varieties, and particularly those which contain large quantities of iron pyrites, are, in most instances, subjected to roasting in a separate furnace.

In order to understand more clearly the operation of smelting in furnaces of this description, we will suppose that a charge has just been tapped off, and that, after thoroughly clearing the hearth, a fresh charge of raw ores has been introduced. During the first part of the operation of roasting, which usually occupies about two hours, the doors are taken off to admit free access of air, and also for the purpose of cooling the furnace, which has been strongly heated at the close of the preceding operation. No fuel is at this period charged upon the grate, since the heat of the furnace is of itself sufficient to effect the elimination of the first portions of sulphur. The ore is carefully stirred, for the purpose of constantly presenting a fresh surface to oxidising influences, and when white fumes are no longer observed to pass off in large quantities, a little coal may be thrown on the grate, and the temperature gradually elevated until the charge becomes slightly clammy and adheres to the rake. When the roasting is considered as being sufficiently advanced, the smelter turns his attention to the state of the fire, taking care to remove the clinkers and get the grate into proper condition for the reception of a fresh supply of fuel. The furnace doors are now closed, and a strong heat is kept up for about a quarter of an hour, when the smelter examines the condition of his charge by removing one of the doors. If the operation is progressing satisfactorily, and the lead flowing freely and passing without obstruction into the tap, the firing is continued a little longer; but when the ores have been found to have taken fire, or are lying unevenly on the bottom of the furnace, the position of the charge is changed by the use of an iron paddle. During this operation the furnace becomes partially cooled, and the reduction of temperature thus obtained is frequently found to produce decompositions, which facilitate the reduction of the charge. In the case of extremely refractory ores this alternate heating and cooling of the furnace is sometimes almost indispensable, whilst, in other instances, their being raked over once or twice, is all the manipulation that is required.

We will suppose that four hours have now elapsed since the charging of the furnace, and that the charge has run down the inclined sole towards the tap. The smelter now examines the condition of the scoriæ and adds a couple of shovelfuls of lime and three or four shovelfuls of small coals, the amount and relative proportions of these being regulated in accordance with the aspect of the slags. The charge is now, by means of proper tools, again raised to the breast of the furnace, and the firing continued until the charge has run down into the tap hole. The foreman now takes his rake and feels if any lumps remain in an unfused condition, and if he finds all to be in a fluid state he calls his assistant from the other side, and, by the addition of a small quantity of lime and fine coal, makes the slag assume a pasty or rather doughy consistency. By the aid of his paddle he now pushes this compound up to the opposite side of the furnace, where it is drawn by an assistant through the back door into a

trough containing water. Whilst the assistant is doing this the foreman is busily engaged in tapping off the metal into the iron pan in front of the furnace, from which, when sufficiently cooled, it is laded out into suitable moulds.

The total duration of the operation may be about six hours.

To build a furnace of the above description, 5,000 common bricks, 2,000 fire bricks, and 2½ tons of fire-clay are required. In addition to this must be reckoned the iron-work, the expense of which will be much influenced by the nature of the armatures employed and the locality in which the furnace is constructed.

The amount of fuel employed for the treatment of a ton of lead ore varies not only in relation to the richness of the mineral, but is also much influenced by the nature of the associated matrix and the calorific value of the fuel itself. The loss of metal experienced during the operation is mainly dependent on the richness of the ore treated and the skill and attention of the foreman.

In the North about 12 cwt. of coal are consumed in the elaboration of one ton of ore, and the loss of metal on 60 per cent. ore may be estimated at about 12 per cent., of which about 6½ per cent. is subsequently recovered from the slag and fumes. At a well-conducted smelting works, situated in the west of England, in which the average assay of the ores smelted during the year was 75½, the yield from the smelting furnaces was 68½ per cent., and the coal used per ton of ore was 13¾ cwts. The lead recovered from the slag and fumes amounted to 2¾ per cent., making the total yield of metal 71¼ per cent., and the loss on the assay produce 4¼ per cent.

In this establishment the men are paid from 7s. 6d. to 12s. 6d. per ton of lead, in accordance with the nature of the ores operated on.

In one establishment the process before described is somewhat varied. The charge employed is 21 cwt. This is run down and tapped off at the expiration of 6 hours, and about nine pigs of 1¼ cwt. each usually obtained. A second charge of 21 cwt. is then dopped in, and, as soon as it is roasted, mixed with the slags of the former operation. The whole is then run down in the ordinary way, the slags drawn and the lead tapped off in nine hours. The produce of the second or double charge is from 14 to 15 pigs.

If the ores are difficult to flow, 16 to 16½ hours are required for the two charges. A small quantity of black slag from the slag hearth is employed for drying up.

Slag Hearth.—The various slags obtained from the different operations of lead smelting are divided into two classes. Those which do not contain a sufficient amount of metal to pay for further treatment are thrown away as useless, whilst those in which the per centage of lead is sufficiently large are treated by the slag hearth.

This consists of a small blast-furnace, having the form of a rectangular prism, about 25 inches in length, 22 inches in breadth, and 33 inches in height. The bottom is composed of a thick cast-iron pan, which is made to incline slightly from the tuyere towards the breast of the furnace. Cast-iron bearers are placed on each side of the iron plate, and on these is supported the fore-hearth, which consists of two stout plates of cast iron. A space of about 5 inches is thus left between the front and bottom of the furnace and an additional height of 2½ inches is obtained by placing between them a row of fire-bricks laid on their flat.

The slags escaping through the opening in the breast of this arrangement sometimes flow into a cistern of water sunk in the earth. This causes the slags to divide into small fragments, and thus adapts them for the process of washing, when it is intended to subject them to this operation. Before starting a furnace of this description, its bottom is filled to a depth of a foot or fifteen inches with small spongy cinders rather closely packed together, and which reach to within four or five inches of the orifice of the tuyere; the breast pan is also filled with cinders which are intended to act as a kind of filter in the separation of metallic lead from the slags. The furnace is frequently lighted by the aid of a small quantity of peat, and when this has become fairly ignited, some good hard coke is thrown in, and as soon as it appears to be sufficiently inflamed, a stratum of grey slag or any other substance to be treated, is introduced. From this time, the hearth is supplied with alternate strata of fuel and slag. The lead obtained from the slag hearth is, from the high temperature at which it is produced, always harder, and therefore inferior in quality to that procured directly from the ores in the reverberatory furnace, and this process is consequently never applied to the treatment of products that admit of being economically worked by the furnace before described.

In addition to being employed for the reduction of slags, this apparatus is sometimes applied to the elaboration of ores of low produce, in the treatment of which the object sought is rather the extraction of the silver they contain, than the reduction of the largest possible amount of lead.

Instead of being blown by a cold blast, these furnaces are sometimes supplied with heated air. When smelting with cold air, it is often found difficult to proportion the quantity of slag or other substance operated on, so as to preserve the nose or cone of slag which forms at the end of the tuyere from growing too long, to the prejudice of the operation. When the substance operated on is poor for metal, and very refractory, it frequently happens that the smelter is obliged to break the nose, or introduce some very fusible substance in order to melt it off. By the introduction of hot air this inconvenience is removed, since by increasing or lowering the temperature of the blast, the nose may be allowed to lengthen or shorten, according as the nature of the slags may require. The temperature found to answer best is from 250° to 300° Fahr.; since when it is heated to from 500° to 600°, it is found impossible to form a nose of sufficient length to convey the blast to the front of the hearth and therefore the back, which is expensive to rebuild, is quickly destroyed.

The advantage to be derived from the use of the hot blast will be evident, from the result of two experiments which were tried some years since.

Twenty-eight tons of slag smelted with cold blast consumed 392 cubic feet of air per minute.

Labour cost	£3	7	8
Coke, 7 tons, at 24s. 6d.........	8	11	6
Total	£11	19	2

Thirty-five tons of similar slag smelted with hot blast consumed 300 cubic feet of air per minute.

Labour cost	£3	7	8
Coke, 5 tons, 17 cwt., at 24s. 6d............	7	3	4
Turf for heating air, 11 loads, 1s. 8d...	0	18	4
Total	£11	9	4

From which it will be seen that, with one-quarter part less air, a quarter part more slag was melted per week, and a saving in expense of 10s. effected.

The loss of lead experienced in smelting by the slag hearth, is, however, very great, even under the most favourable circumstances; and it has consequently, of later years, been gradually superseded by the Castillian furnace, which will be shortly described. Many large and well-conducted establishments still however continue to employ the slag hearth, and, when well constructed and skilfully managed, the loss arising from volatilisation may be considerably reduced.

Scotch Hearth.—Instead of the reverberatory furnace, the Scotch hearth may frequently be employed with advantage for the treatment of lead ores of a good produce. This consists of a rectangular cavity, lined with cast-iron,

and of which the dimensions vary in different localities, although it is frequently made about 2ft. square.

The bottom is also of cast-iron, and is surrounded by a ledge about five inches in height, with the exception of the side nearest the work-stone, which is of iron, and may be about 20 inches in breadth. This plate is made to have a fall of about six inches on its whole breadth; its upper side rests on the hearth bottom, or in some instances is united with it, only forming one casting. On the back edge of the furnace bottom is placed a prism of cast-iron, called a back-stone, and on this rests the nozzle of the tuyere, over which is again placed another block of the same metal, called a pipe-stone, and on this again is placed another back-stone, which completes this side of the hearth. Along the two lateral edges of the hearth-bottom are laid two prismatic castings, called bearers, which project slightly over the upper edge of the work-stone. Above these bearers is a prism of cast-iron called a fire-stone, the space at each end being closed by cubes of cast-iron called key-stones.

Before the work-stone, and set in masonry, is the lead-pot, into which the melted metal as it issues from the hearth, is conducted by an oblique channel sunk beneath the surface of the iron plate. To prevent the escape of fumes into the smelting-house, the whole is covered by a hood of arched bricks, which is provided with a sheet-iron front. The blast introduced through the tuyere is regulated by a throttle-valve, and the brick-work is consolidated and bound together by heavy iron straps, kept in their places by screw-bolts passing through the masonry. The ores treated in the Scotch hearth are usually roasted in a separate furnace, for the purpose of effecting their partial desulphuration and oxidation before undergoing the process of smelting.

At the termination of every shift, a quantity of ore remains on the hearth in a semi-reduced state called browse, and is more or less mixed with fragments of coke and clinker, from which it is afterwards roughly separated.

To commence a new shift, the cavity of the furnace is filled with peat cut into blocks; those at the back are heaped up without any kind of order, but those towards the front are arranged in the shape of a wall. The blast is now turned on, and an ignited fragment of peat thrown immediately before the nozzle, which quickly communicates combustion to the whole mass. On the top of this a few shovelfuls of coal are subsequently placed, and the browse resulting from the preceding operation is then charged on the top of the ignited mass, and shortly afterwards a portion of the molten matter in the internal basin is drawn on to the work-stone. The grey slag is now removed, and thrown on one side of the furnace, and the browse, thus freed from slag, again returned to the hearth, with the addition of a little coal. If, as is sometimes the case, it has not been properly freed from slag, and therefore exhibits a disposition to fuse, it must be hardened by the addition of a small quantity of quicklime, which dries up the materials in such a way as to facilitate the subsequent extraction of the lead. When, on the contrary, the ore is found too refractory, a small quantity of lime, or of lime and fluor-spar is added, but in this case a less amount of lime is employed, as it is intended as a flux and not as a drier of a too fusible slag. The slag thus obtained still contains a notable amount of lead, and is subsequently treated in the slag hearth.

When the whole of the browse has been thrown back into the hearth, a few shovelfuls of roasted ore are distributed over it; before doing this, however, the scoriæ are removed, and a lump of peat is placed before the tuyere, which not only prevents any of the mineral from entering the nozzle, but also from its porosity, seems to equalise and distribute the air through the mass.

After another interval of about twenty minutes, the contents of the hearth are again drawn out on the work-stone, and another portion of metallic lead obtained. The grey slag is removed, and another lump of peat placed before the tuyere; the browse, together with a proper quantity of coal and quick lime, is again thrown upon the fire, and on the top is laid a fresh supply of roasted ore. The Scotch hearth will, in accordance with the nature of the ore treated, yield from one to two tons of metallic lead per shift, and usually affords softer metal than the reverberatory furnace.

In an establishment in the North, where the Scotch hearth is employed, and in which the ores treated contain on an average 73 per cent. of metal, the following results are obtained:—

The lead reduced at the first fire amounts to 60 per cent., but 3·20 per cent. are subsequently obtained from the slags, and 6·91 per cent. from the fumes, making the ultimate loss on the assay produce 2·90 per cent.

The materials employed for the elaboration of one ton of ore are as follows:—

	cwt.	qrs.	lbs.	cwt.	qrs.	lbs.
Coals for smelting	1	2	4	3	1	15
,, ,, calcining	1	3	11			
Peat or turf, ...				0	3	0
Lime				0	2	0
Total				4	2	15

To construct an ore hearth 2,000 common bricks, and the same quantity of fire-bricks are required, together with about 1½ tons of fire clay.

Castillian Furnaces.—Within the last few years a blast furnace has been introduced into the lead works of this country, which possesses great advantages over every other description of apparatus which has been hitherto employed for the treatment of lead ores of low produce. This apparatus, although first employed in Spain, was I am informed, invented by an Englishman (Mr. W. Goundry) who was employed in the reduction of rich slags in the neighbourhood of Carthagena.

This furnace is circular, usually about 2 feet 10 inches, or 3 feet in diameter, and is constructed of the best fire-bricks, so moulded as to fit together, and allow all the joints to follow the radii of the circle described by the brick work. Its usual height is 8 feet 6 inches, and the thickness of the masonry invariably 9 inches. In this arrangement the breast is formed by a semi-circular plate of cast-iron, furnished with a lip for running off the slag, and has a longitudinal slot, in which is placed the tapping-hole.

On the top of this cylinder of brickwork a box-shaped covering of masonry is supported by a cast-iron framing, resting on four pillars, and in this is placed the door for feeding the furnace, and the outlet by which the various products of combustion escape to the flues. The lower part of this hood is fitted closely to the body of the furnace, whilst its top is closed by an arch of 4½ inch brickwork laid in fire-clay. The bottom is composed of a mixture of coke-dust and fire-clay, slightly moistened, and well-beaten to the height of the top of the breast-pan, which stands nearly 3 feet above the level of the floor. Above the breast-pan is an arch, so turned as to form a sort of niche, 18 inches in width, and rather more than 2 feet in height.

When the bottom has been solidly beaten, up to the required height, it is hollowed out so as to form an internal cavity, communicating freely with the breast-pan, which is filled with the same material and subsequently hollowed out to a depth slightly below the level of the internal cavity. The blast is supplied by three water tuyeres, 3 inches in diameter at the smaller end, 5½ inches at the larger, and 10 inches in length. Into these the nozzles are introduced, by which a current of air is supplied by means of a fan or ventilator, making about 800 revolutions per minute. The blast may be conveniently conducted to the nozzle through brick channels formed beneath the floor of the smelting house.

The ores treated in this furnace ought never to contain more than 30 per cent. of metal, and when richer, must be reduced to about this tenure by the addition of slags and other fluxes. In charging this apparatus, the coke and ore

are supplied stratum super stratum, and care must be taken so to dispose the coke as not to heat too violently the brickwork of the furnaces.

In order to allow the slags which are produced to escape freely into the breast-pan, a brick is left out of the front of the furnace at the height of the fore-hearth, which, for the purpose of preventing the cooling of the scoriæ, is kept covered by a layer of coke-dust or cinders. From the breast-pan the slags flow constantly off over a spout into cast-iron waggons, where they consolidate into masses, having the form of truncated pyramids, of which the larger base is about 2 feet square. As soon as a sufficient amount of lead has accumulated in the bottom of the furnace, it is let off into a lateral lead pot, by removing the clay-stopper of the tap hole situated in the slot of the breast-pan, and after being properly skimmed it is laded into moulds. When in addition to lead the ore treated likewise contains a certain portion of copper, this metal will be found in the form of a matt floating on the surface of the leaden bath. This, when sufficiently solidified, is removed, and after being roasted is operated on for the copper it contains.

The waggons in which the liquid slag runs off, are frequently made to traverse small railways by which, when one mass has been removed, its place may readily be supplied by an empty waggon. When nearly cold the casings of the waggons are turned over and the blocks of slag easily made to drop out. In addition to the facility for transport obtained in this way, one of the great advantages obtained by this method of manipulation arises from the circumstance that should the furnaces at any time run lead or matt, without its being detected by the smelter, the whole of it will be collected at the bottom of the block, from which, when cold, it may be readily detached.

In working these furnaces, care must be taken to prevent flame from appearing at the tunnel-head, since, provided the slags are sufficiently liquid, the cooler the apparatus is kept the less will be the loss of metal through volatilisation. In addition to the greatest attention being paid to the working of the furnace, it is necessary, in order to obtain the best results, that all establishments in which this apparatus is employed should be provided with long and capacious flues, in which the condensation of the fumes takes place, previous to arriving at the chimney-shaft. These flues should be built three feet in width, and six feet in height, so as readily to admit of being cleaned, and are often made of several hundred feet in length. The value of the fumes, so condensed, amounts to many hundreds, and in some instances thousands per annum.

In order to be advantageously worked in these furnaces, the ores should be first roasted, and subsequently agglomerated into masses, which, after being broken into fragments, of about the size of the fist, and mixed with the various fluxes, are charged as before described.

In an establishment in which the average assay produce of the roasted ore for lead is $42\frac{4}{5}$ths, the furnace yield is $38\frac{13}{14}$ths, and the weight of coke employed to effect the reduction 22 per cent. of the roasted ore operated on. The mixture charged into the furnace, in this instance, is composed of 100 parts of roasted ore, 42 parts of slags, from a previous operation, 8 parts of scrap iron, and 7 parts of limestone. Each furnace works off about seven tons of roasted ore in the course of 24 hours; the weight of slags run off is about double that of the lead obtained, and the matt removed from the surface of the pan is nearly 5 per cent. of the lead produced. The ores treated in this establishment consist of galena, much mixed with spathose iron, and are therefore somewhat refractory. A furnace of this kind requires for its construction about 1,200 segmental fire-bricks, and the same number of ordinary fire-bricks of second quality.

The desulphuration of the ores to be treated in these furnaces may be effected either by the aid of an ordinary reverberatory roasting furnace, or in heaps, or properly constructed kilns.

The kilns best adapted for this purpose consist of rectangular chambers having an arched roof, and provided with proper flues for the escape of the evolved gases, as well as a wide door for charging and withdrawing the ore to be operated on.

Each of these chambers is capable of containing from 25 to 30 tons of ore, and in order to charge it a layer of faggots and split wood is laid on the floor, and this, after having been covered by a layer of ore, about two feet in thickness, is ignited, care being, at the same time, taken to close, by means of loose brick-work, the opening of the door to the same height. When this first layer has become sufficiently ignited, a fresh stratum of ore, mixed with a little coal or charcoal, is thrown upon it, and when this layer has in its turn, become sufficiently heated, more ore is thrown on. In this way more ore is every day added, until the kiln has become full, when the orifice of the doorway is closed by an iron plate, and the operation proceeds regularly and without further trouble until the greater portion has become eliminated.

This usually happens at the expiration of about four weeks from the time of first ignition, and the brick-work front is then removed, and the ores broken out, and after being mixed with proper fluxes, passed through the blast furnace.

The proportion of wood necessary for the roasting of a ton of ore by this means must necessarily depend on the composition of the minerals operated on, but with ores of the description above-mentioned, and in a neighbourhood where wood is moderately cheap, the desulphuration may be effected at a cost of about 5s. per ton.

Calcining.—The lead obtained by the various processes above described generally contains a sufficient amount of silver to render its extraction of much importance; but, in addition to this, it is not unfrequently associated with antimony, tin, copper, and various other impurities, which require to be removed before the separation of the silver can be effected.

This operation consists in fusing the hard lead in a reverberatory furnace of peculiar construction, and allowing it to remain, when in a melted state, exposed to the oxidising influences of the gases passing through the apparatus. By this treatment the antimony, copper, and other impurities become oxidised, and on rising to the surface of the metallic bath are skimmed off, and removed with an iron rake. The hearth of the furnace in which this operation is conducted consists of a large cast-iron pan, which may be 8 feet in length, 5 feet 6 inches in width, and 10 inches in depth. The fire-place, which is 1 foot 8 inches in width, has a length equal to the width of the pan, and is separated from it by a fire-bridge 2 feet in width. The height of the arch at the bridge end is 1 foot 4 inches above the edge of the pan, whilst at the outer extremity it is only about 8 inches.

The lead to be introduced into the pan is first fused in a large iron pot fixed in brick-work at the side of the furnace, and subsequently ladled into it through an iron gutter adapted for that purpose. The length of time necessary for the purification of hard lead obviously depends on the nature and amount of the impurities which it contains; and, consequently, some varieties will be sufficiently improved at the expiration of twelve hours, whilst in other instances it is necessary to continue the operations during three or four weeks. The charge of hard lead varies from eight to eleven tons.

When the metal is thought to be in a fit state for tapping, a small portion taken out with a ladle, and poured into a mould used for this purpose is found on cooling to assume at the surface a peculiar crystallised appearance, which when once seen is readily again recognised. As soon as this appearance presents itself an iron plug is withdrawn from the bottom of the pan, and the lead run off into an iron pan, from which it is subsequently laded into moulds.

The items of cost attending the calcination of one ton of hard Spanish lead in the north of England are about as follows:—

	s.	d.
Wages	1	11·2
Coals 2·7 cwt		4·7
Repairs, &c.	1	0·5
	3	4·4

The construction of a furnace of this description requires 5000 common bricks, 3,500 fire-bricks, and 2 tons of fire clay.

CONCENTRATION OF THE SILVER.—This process is founded on the circumstance first noticed in the year 1829, by the late H. L. Pattinson of Newcastle-on-Tyne, that when lead containing silver is melted in a suitable vessel, afterwards slowly allowed to cool, and at the same time kept constantly stirred, at a certain temperature near the melting point of lead metallic crystals begin to form. These as rapidly as they are produced, sink to the bottom, and on being removed are found to contain much less silver than the lead originally operated on. The still fluid portion, from which the crystals have been removed, will at the same time be proportionally enriched.

This operation is conducted in a series of eight or ten cast-iron pots, set in a row, with fire-places beneath. These are each capable of containing about 6 tons of calcined lead; and on commencing an operation that quantity of metal, containing, we will suppose 20 oz. of silver per ton, is introduced into a pot (say No. 4) about the centre of the series. This, when melted, is carefully skimmed with a perforated ladle, and the fire immediately withdrawn. The cooling of the metal is also frequently hastened by throwing water upon its surface, and whilst cooling it is kept constantly agitated by means of a long iron stirrer or slice. Crystals soon begin to make their appearance, and these as they accumulate and fall to the bottom are removed by means of a large perforated ladle, in which they are well shaken, and afterwards carried over to the next pot to the left of the workman. This operation goes on continually until about 4 tons of crystals have been taken out of the pot No. 4, and have been placed into pot No. 5, at which time the pot No. 4 may contain about 40 oz. of silver to the ton, whilst that in No. 5 will only yield 10 oz. The rich lead in No. 4 is then laded into the next pot No. 3, to the right of the workman, and the operation repeated in No. 4, on a fresh quantity of calcined lead.

In this way calcined lead is constantly introduced, and the resulting poor lead passes continually to the left of the workman, whilst the rich is passing towards his right. Each pot in succession, when filled with lead of its proper produce for silver, is in its turn crystallised, the poor lead passing to the left of the workman, and the enriched lead to his right. By this method of treatment it is evident that the crystals obtained from the pots to the left of the workman must gradually be deprived of their silver, whilst the rich lead passing to his right becomes continually richer. The final result is, that at one end of the series, the poor lead contains very little silver, whilst at the other an exceedingly rich alloy of lead and silver is obtained.

The poor lead obtained by this process should never contain more than 12 dwts. of silver per ton, whilst the rich lead is frequently concentrated to 500 oz. to the ton. This rich lead is subsequently cupelled in the refining furnace.

The ladle employed for the removal of the crystals, when manual labour is made use of, is about 16 inches in diameter, and 5 inches in depth, but when cranes are used much larger ladles are easily managed. A form of crane has been invented by Mr. J. Sparks, which effects considerable economy of labour. When, during the operation of crystallisation, the ladle becomes chilled it is dipped into a small vessel containing lead of a higher temperature than that which is being worked, and known by the name of a temper-pot. The pot containing the rich lead is often called the No. 1 pot; in some establishments, however, the last pot in which the pure lead is crystallised obtains this appellation.

The cost of crystallising one ton of calcined Spanish lead, in the establishment quoted when treating of calcination, is as follows:—

	s.	d.
Wages	9	5·4
Coals, 4 cwts.	0	8·4
Repairs	0	2·5
Total	10	4·3

The erection of nine six-ton pots requires 15,000 common bricks, 10,000 fire-bricks, 160 feet of quarles, 80 fire-clay blocks, and 5 tons of fire-clay.

In some establishments ten-ton pots are employed, and where cranes are made use of they are found to be advantageous.

REFINING.—The extraction of the silver contained in the rich lead is conducted in a cupel forming the bottom of a reverberatory furnace called a refinery.

In this operation the litharge produced, instead of being absorbed by the substance of the cupel, is run off in a fluid state, by means of a depression called a gate.

The size of the fire-place varies with the other dimensions of the furnace, but is usually nearly square, and in an apparatus of ordinary size may be about 2 feet by 2 feet 6 inches. This is separated from the body of the furnace by a fire-bridge 18 inches in breadth, so that the flame and heated air pass directly over the surface of the cupel, and from thence escape by means of two separate apertures into the main flues of the establishment. The cupel or test consists of an oval iron ring, about 5 inches in depth, its greatest diameter being 4 feet, and its lesser nearly 3 feet. This frame, in order to better support the bottom of the cupel, is provided with cross bars about 4½ inches wide, and one half inch in thickness. In order to make a test, this frame is beaten full of finely-powdered bone-ash, slightly moistened with water, containing a small quantity of pearl-ash in solution, which has the property of giving consistency to the cupel when heated.

The centre of the test, after the ring has been well-filled with this mixture, and solidly beaten down, is scooped out with a small trowel, until the sides are left 2 inches in thickness at top, and three inches at the bottom, whilst the thickness of the sole itself is about 1 inch.

At the fore part or wide end of the test the thickness of the border is increased to six inches, and a hole is then cut through the bottom, which communicates with the openings or gates by which the fluid litharge makes its escape.

The test, when thus prepared, is placed in the refinery furnace of which it forms the bottom, and is wedged to its proper height against an iron ring firmly built into the masonry. When this furnace is first lighted, it is necessary to apply the heat very gradually, since if the test were too strongly heated before it became perfectly dry, it would be liable to crack. As soon as the test has become thoroughly dry, it is heated to incipient redness, and is nearly filled with the rich lead to be operated on, which has been previously fused in an iron pot at the side of the furnace, and beneath which is a small grate where a fire is lighted.

The melted lead, when first introduced into the furnace, becomes covered with a greyish dross, but on further increasing the heat, the surface of the bath uncovers, and ordinary litharge begins to make its appearance.

The blast is now turned on, and forces the litharge from the back of the test up to the breast, where it passes over the gate, and falls through the aperture between the bone-ash and the ring into a small cast-iron pot running on wheels. The air, which is supplied by a small ventilator, not only sweeps the litharge from the surface of the lead towards the breast, but also supplies the oxygen necessary for its formation.

In proportion as the surface of the lead becomes depressed by its constant oxidation, and the continual removal of the resulting litharge, more metal is added from the melting pot, so as to raise it to its former level, and in this manner the operation is continued until the lead in the bottom of the test has become so enriched as to render

it necessary that it should be tapped. The contents of the test are now so far reduced in volume that the whole of the silver contained in the rich lead operated on remains in combination with a few hundred weights only of metal, and this is removed by carefully drilling a hole in the bone-ash forming the bottom of the test. The reason for the removal of the rich lead, is to prevent too large an amount of silver from being carried off in the litharge, which is found to be the case when lead containing a very large amount of that metal is operated on.

When the rich lead has been thus removed, the tapping hole is again closed by a pellet of bone-ash, and another charge immediately introduced.

As soon as the whole of the rich lead has been subjected to cupellation, and has become thus further enriched, the argentiferous alloy is itself similarly treated, either in a fresh test, or in that employed for the concentration of the rich lead. The brightening of pure silver at the moment of the separation of the last traces of lead, indicates the precise period at which the operation should be terminated, and the blast is then turned off, and the fire removed from the grate. The silver is now allowed to set, and as soon as it has become hardened, the wedges are removed from beneath the test, which is placed on the floor of the establishment. When cold, the silver plate is detached from the test, and any adhering particles of bone-ash removed by the aid of a wire brush.

A test furnace of ordinary dimensions requires for its construction about 2,000 common bricks, 2,000 fire-bricks and 1½ tons of fire-clay. A furnace of this kind will work off 4 pigs of lead per hour, and consume 4 cwts. of coal per ton of rich lead ore operated on.

The cost of working a ton of rich lead in the neighbourhood of Newcastle, containing on an average 400 oz. of silver per ton, is as follows:—

	s.	d.
Refiner's wages	4	2·1
Coals 4 cwt	0	6·8
Engine wages	1	7·0
Coals 5 cwt	0	8·7
Pearl-ash	0	3·5
Bone-ash 17·3 lbs	3	1·0
Repairs	0	5·0
Total	10	10·1

Reducing.—The reduction to the metallic state of the litharge from the refinery, the pot dross, and the mixed metallic oxides from the calcining furnace is effected in a reverberatory apparatus, somewhat resembling a smelting furnace, except that its dimensions are smaller, and the sole, instead of being lowest immediately below the middle door, gradually slopes from the fire-bridge to near the flue, where there is a depression in which is inserted an iron gutter which constantly remains open and from which the reduced metal flows continuously into an iron pot placed by the side of the furnace for its reception, whence it is subsequently laded into moulds.

The litharge, or pot dross, is intimately mixed with a quantity of small coal, and is charged on that part of the hearth immediately before the fire-bridge. To prevent the fused oxide from attacking the bottom of the furnace, and also to provide a sort of hollow filter for the liquid metal, the sole is covered by a layer of bituminous coals.

The heat of the furnace quickly causes the ignition of this stratum, which is rapidly reduced to the state of a spongy cinder. The reducing gases present in the furnace, aided by the coal mixed with the charge itself, cause the reduction of the oxide, which, assuming the metallic form, flows through the interstices of the cinder, and ultimately finding its way into the depression at the extremity of the hearth, flows through the iron gutter into the external cast iron pot. The surface of the charge is frequently, during the process of elaboration, turned over with an iron rake, for the double purpose of exposing new surfaces to the action of the furnace, and also to allow the reduced lead to more readily flow off.

Fresh quantities of litharge or pot-dross, with small coals, are from time to time thrown in, in proportion as that already charged disappears, and at the end of the shift, which usually extends over 12 hours, the floor of cinder is broken up, and after being mixed with the residual matters in the furnace is withdrawn. A new floor of cinders is then introduced, and the operation commenced as before. A furnace of this kind, having a sole 8 feet in length and 5 feet in width, will afford, from litharge, about 4¼ tons of lead in 24 hours, and will consume 20 cwt. of coals.

The dross from the calcining pan, when treated in a furnace of this description, should be previously reduced to a state of fine division, and intimately mixed up with small coal and a soda-ash. In many cases, however, the calcined dross is treated in the smelting furnace. The hard lead obtained from this substance is again taken to the calcining furnace, for the purpose of being softened.

The expense of reducing one ton of litharge may be estimated as follows:—

	s.	d.
Wages	2	6·0
Coals (3 cwts.)	0	5·2
Repairs	0	1·6
Total	3	0·8

In the establishment from which the foregoing data were obtained, the cost of slack, delivered at the works, was only 2s. 11d. per ton, which is cheaper than fuel can be obtained in the majority of the lead-mills of the country. In North Wales the cost of small coal is generally about 4s., and at Bristol 5s. 6d. per ton.

The total cost of elaborating one ton of hard lead, containing 30 oz. of silver per ton, in a locality in which fuel is obtained at the low price above quoted, is nearly as follows:—

	£	s.	d.
Calcining	0	2	4·5
Crystallising	0	9	6·5
Refining	0	0	9·2
Reducing—pot dross and litharge	0	1	0·8
Calcined dross	0	0	8·0
Slags	0	0	5·0
Bone-ash, &c.	0	0	7·0
Transport, &c.	0	1	1·0
Management, taxes, and interest of plant	0	5	10·0
Total	£1	2	4·0

One hundred tons of hard lead treated gave—

	Tons.
Soft lead	94·90
Black dross	3·72
Loss	1·38
Total	100·00

On comparing the expense of each operation, as given in the foregoing abstract, with the amounts stated as the cost of each separate process, they will be found to be widely different, but it must be remembered that the whole of the substances elaborated are far from being subjected to the various treatments described.

In order therefore to give an idea of the relative proportions which are passed through the several departments, I may state that in an establishment in which the ores are treated in the Castillian furnace the following are the results obtained:—

One-hundred parts of raw ore yield:—	
Roasted ore	85
Hard lead	42
Soft "	36
Rich "	9
Dross and litharge re-treated	18½

The importance of this branch of our metallurgic industry will be gathered from the following tabular statements, chiefly derived from Mr. Hunt's valuable statistics:—

TABLE I.

TABLE showing the quantity of Lead Ore raised and smelted, average Metallic yield of Ore per cent., and Ratio of Lead produced in various parts of the United Kingdom during ten years ending 1857.

YEARS.	ENGLAND.		WALES.		IRELAND.		SCOTLAND.		ISLE OF MAN.		TOTAL.	
	Lead Ore.	Lead.	Lead Ore.	Lead.	Lead Ore.	Lead.	Lead Ore.	Lead.	Lead Ore.	Lead.	Lead Ore.	Lead.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1848	54,538	39,142	16,305	11,122	1,912	1,188	2,588	1,736	2,521	1,665	77,864	54,853
1849	60,124	41,168	19,711	13,389	2,739	1,653	1,421	957	2,826	1,535	86,821	58,702
1850	63,565	44,462	21,093	14,876	2,895	1,746	3,117	2,124	2,175	1,218	92,845	64,426
1851	64,102	45,103	19,314	14,813	3,222	1,829	3,113	2,140	2,560	1,402	92,311	65,287
1852	62,411	43,813	18,379	13,708	4,493	3,222	3,499	2,381	2,415	1,835	91,197	64,959
1853	59,342	41,897	17,131	12,870	3,309	2,452	2,799	1,919	2,460	1,829	85,041	60,967
1854	64,796	44,986	18,130	13,367	3,069	2,210	1,753	1,279	2,800	2,137	90,548	63,979
1855	66,270	46,244	18,206	13,673	2,405	1,732	1,587	1,159	3,573	2,725	92,041	65,533
1856	74,489	52,868	19,873	14,791	2,484	1,602	1,931	1,417	3,218	2,451	101,997	73,129
1857	68,520	48,356	21,455	16,124	2,299	1,407	1,891	1,351	2,656	2,028	96,821	69,266
	638,157	448,039	189,597	138,733	28,827	19,041	23,699	16,463	27,204	18,825	907,486	641,101
Average Metallic yield per cent. of Ore... ...	70·2		73·1		66·0		69·4		69·1		70·6	
Ratio of Lead produced ...	69·9		21·7		3·0		2·5		2·1		= 100	

TABLE II.

Estimated value of Lead and Silver consumed in Great Britain 1857.

Lead and Silver produced in the United Kingdom ...		£1,670,353
Silver imported, 846,569 oz.		232,806
		1,903,159
Lead exported..................	22,397 tons.	
,, imported	12,768 ,,	
Balance of exports	9,629...........................	211,838
Value consumed..................................		1,691,321

TABLE III.

Silver produced from Ores raised in Great Britain, during Four Years, ending 1857.

	1854.	1855.	1856.	1857.
	Ozs.	Ozs.	Ozs.	Ozs.
England	419,824	439,983	481,909	417,343
Wales	67,051	57,521	62,357	58,097
Ireland..........................	18,096	7,252	3,700	3,071
Scotland	5,426	4,947	5,289	4,206
Isle of Man............ ..	52,262	51,597	60,382	48,016
	562,659	561,300	613,637	530,733
Value at 5s. 6d. per oz....	£154,730	£154,357	£158,750	£146,501

Market Value of Lead produced in the United Kingdom in 1857..	£1,523,852
Ditto of Silver..	146,501
	£1,670,353

It would be evidently impossible to comprise within the limits of a single paper a description of the whole of the various processes employed in different parts of the world for the reduction of lead from its ores, and I have consequently confined myself to an exposition of the general routine of the operations commonly practised in this country.

In doing this it has been my endeavour to furnish reliable data as to the expenses and losses incurred in each operation, and although it would have been easy to have multiplied examples, want of space has prevented my doing so.

It is in the treatment of ores of good produce that the reverberatory furnace and Scotch hearth are to be preferred, but for working minerals of a low per centage the blast furnace may generally be substituted with advantage. The slag hearth, from the amount of fuel consumed and loss experienced, is a somewhat expensive apparatus, and might, in many cases, be advantageously exchanged for the Castillian furnace.

It is well-known that the losses which take place in this branch of metallurgy are, from the volatility of the metal operated on, unusually large. In those establishments, however, in which due attention is paid to fluxes and a proper admixture of ores, as well as the condensation of the fumes, a great economy is effected.

In lieu of long and extensive flues, condensers of various descriptions have from time to time been introduced, but in most instances the former have been found to be more efficient.

DISCUSSION.

The CHAIRMAN said, if he understood rightly the objects of the Society of Arts, he thought that such papers as the one brought before them that evening fully carried out its intention. Mr. Phillips had detailed to them the processes which were employed in the smelting of lead ores up to the latest improvements which had been introduced. Still it would be admitted by him, and he was sure it would be admitted by others familiar with the subject, that there remained great improvements to be made, for we were still suffering an enormous loss from the imperfections of even the best known processes. They might therefore hope that some gentlemen might be induced to offer some remarks upon these points, and the result might be the quickening of some dormant thought, which might lead to improvements in this branch of manufacture. He thought it would not be out of place to refer to one individual to whom we were specially indebted for much progress in this department of metallurgy. Mr. Phillips had referred to the process invented by Mr. Hugh Lee Pattinson for extracting the silver from lead ores. Within the last year that gentleman had been taken from them; and he thought this was a legitimate opportunity for acknowledging the debt of gratitude that we owed to him. He was in every respect a remarkable man. When a poor boy, in a small druggist's shop, in the little town of Alston, he taught himself chemistry, never having had an instructor. He was in every sense of the word a self-taught man; and he was a most industrious one, a most earnest worker, and a man of the closet and of the keenest powers of observation. He was led amongst other things, by seeing the process of lead smelting that was going on in his own immediate vicinity, to direct his attention to the means of sepa-

rating the silver from the lead, and after making a series of experiments, he succeeded in producing a process which, for a long period of years, saved not less than 200,000 ounces of silver annually, which had previously been thrown away. Not only had this self-educated man effected this, but he had introduced another useful product from the lead ores, the oxy-chloride of lead, and had also given us a process for the preparation of the carbonate of magnesia from the dolomite, or magnesian limestone of the North of England. There was, however, nothing more remarkable in the career of this distinguished man than the way in which he bestowed the fortune which his industry secured to him, in promoting the best interests of those around him. In the neighbourhood of the works, now carried on by his family, he established schools, in which hundreds of workmen and children were educated. His was, therefore, a name, in connection with this subject, which he could not allow to pass without the brief comments which he had ventured to make.

Mr. Hyde Clarke, on being called upon by the Chairman, said he had not such a practical acquaintance with the various branches of metallurgy as Mr. Phillips possessed, and he had had very little to do with lead smelting. Mr. Phillips' observations, however, had tended very much to draw his attention to one subject which had been adverted to—viz., the importance of considering the operations of smelting as a whole, when working for the improvement of any particular process. It certainly was a great misfortune that in metallurgical pursuits too many practical men were absorbed in their own particular branch without studying the other branches; whereas in reality there were very few processes which, if carefully examined, would not be found capable of affording some hint for the improvement of other departments of metallurgy. It was a subject to which, he trusted, Mr. Phillips himself would be induced to turn his attention for the purpose of carrying out those practical objects which the Chairman had mentioned. There were few branches of metallurgy in which serious losses were not sustained by the employment of some old process, whereas in other departments of industry many important improvements had been introduced. The observation made by the Chairman with reference to the late Hugh Lee Pattinson had brought to his mind another subject—the neglect of so many important mineral products which still existed in this country, notwithstanding all the improvements made. With regard to the particular subject of silver in lead, he had in his own museum specimens collected 50, 60, or 80 years ago, of lead ore containing 40, 60, and 80 ounces of silver to the ton, which were left unwrought for years, because it was considered that they were not susceptible of economical application, whereas, by the improvements introduced, the production of silver in this country had become very considerable, a subject with which no one was better acquainted than the chairman. Those improvements had been the means of realising a very great quantity of silver from ores the produce of this country, besides which, the improvements of Pattinson and others had enabled them to treat a large quantity of foreign ores brought to this country for that purpose. The great increase which had taken place in the production of silver in this country was an encouragement for the carrying out of similar improvements. They had recently had a paper read before the Society upon the utilisation of waste substances, and he would renew the remark which he made on that occasion, viz., that in no branch of manufacture was there greater waste than in their metallurgic operations, and every process by which they could economise the substances now wasted was worthy of the highest consideration.

The Rev. Daniel Ace said, having formerly had the charge of the parish of Alston, it was his privilege to come in contact with the late Mr. Hugh Lee Pattinson, and he could testify that a more humble and liberal-minded man he was never privileged to converse with; for, notwithstanding his high attainments in science, he was ever ready to communicate his knowledge to others, and to do his utmost to promote the happiness of those with whom he was associated. In a religious point of view, he was desirous to promote that independence of thought, as well as liberty of action, which he (Mr. Ace), as a clergyman, conceived to be the glory of mankind.

Mr. Warrington expressed the pleasure he had derived some years since, from a visit to the smelting-works at Alston Moor, at which time, the flue which was suggested by Bishop Watson extended for a distance of three miles. He believed it was now considerably longer. From that place an enormous quantity of soot was annually taken, and he believed as much as 300 tons of lead was derived from that flue, which would have been driven off into the atmosphere as smoke, destroying vegetable and animal life.

Mr. J. A. Phillips said the fumes caught in well-constructed flues, generally amounted to 1 or $1\frac{1}{2}$ per cent. of the lead contained in the ore put into the furnaces; but the amount of silver was very much smaller; and they found that the fumes from ores containing 20 ounces of silver to the ton, would in very few instances contain more than two or three ounces of silver. He had analysed the fumes from different parts of the flue, and had found that in the first 100 yards, the proportion of silver was greater than in the next 100 yards, until, as the chimney was approached there were scarcely any traces of silver. Instead of flues, condensers of various kinds had been employed, which were found very efficacious for the condensation of the fumes, and when employed with the Castillian or other blast furnaces, they did not materially impair the draft, since the furnace was not dependent upon the natural draft, but upon a blast forced in by machinery. When, on the other hand, they made use of reverberatory furnaces, a condensing chamber materially checked the draft from the flue, and every practical lead-smelter would bear him out that it was exceedingly difficult to obtain good results with a furnace having a bad draft. When speaking of the combination of silver and lead in the galenas, he remarked that it would appear in many cases that the sulphide of silver was combined mechanically with the sulphide of lead; whilst, in other cases, the two sulphides were in a state of chemical combination. Alluding to specimens upon the table, Mr. Phillips remarked that in the case of one of them, the silver was almost entirely lost if the ore was treated by washing, whilst in the other the loss of silver, by similar treatment, did not amount to more than two ounces to the ton. In the first case the sulphide of silver was mechanically combined, and in the second it was in a state of chemical combination with the sulphide of lead. Mr. Hyde Clarke had stated that in the metallurgic operations of the present day there was still a great waste of useful products. No doubt such was the case. There was a great want of chemical knowledge in the mining districts of the country. An instance occurred a short time ago, in which large quantities of oxide of iron usually called "gossan," were thrown away from a mine in Cornwall, it never having occurred to them to test it for silver; on its being examined, however, it was found to contain silver to the amount of £15 per ton, and as it was obtainable in large quantities, this discovery materially enhanced the value of the property. He had no doubt that not only silver, but nickel and cobalt existed in much larger proportion in the mineral districts than was generally imagined.

Professor Tennant observed that, on looking over some of the rubbish heaps in Shropshire, which had been cast away as refuse matter, he found a large portion of carbonate of lead, which had been regarded as calcareous spar. There were instances in which the carbonate of lead was apt to be overlooked even by those who had a practical knowledge of mineralogy, and a valuable product was thrown away simply owing to a want of acquaintance with its properties. He fully agreed with the remark that a

better practical education was required amongst the people engaged in mining operations. The late Mr. Hugh Lee Pattinson was one who took that matter in hand, and he was happy to find that the example had been followed in other instances. He would particularly allude to the extensive mines under the superintendence of Mr. Sopwith, where thousands of men were employed. He believed the flue at the works at Alston Moor was nearly five miles in length, instead of three miles, as mentioned by Mr. Warrington. He (Professor Tennant) felt obliged to Mr. Phillips for the way in which he had described the operation of lead smelting, which was of the utmost importance when they considered its extent. With regard to the statistics of this subject, he believed the chairman would corroborate the statement that there was often difficulty in obtaining precise information.

The Chairman said that Mr. Tennant was in error. He could with very great satisfaction say that in his statistical inquiries, with but one exception, he had never been refused the information he asked for.

Professor Tennant was very happy to hear it. He found the value of the metallic minerals in this country was about £16,000,000 per annum; they were therefore a most important part of our national wealth, and any information bearing on the subject was necessarily of great interest. In conclusion, Professor Tennant pointed out the great importance of a more general study of mineralogy, and strongly recommended a visit to the works at Alston Moor, which he said would be highly entertaining as well as instructive.

The Chairman would ask the gentleman who had just addressed them, whether he could give them any information as to the combination of sulphide of silver with sulphide of lead.

Professor Tennant replied, that it was one of those difficult questions which had not yet been fully resolved, like that of the pure silver that was found in the copper of Lake Superior. Whether the combination was chemical or mechanical, he could not say; but his own impression was that the metals were mechanically, and not chemically combined.

Mr. J. A. Phillips said, that some years since he visited the mines of Lake Superior, and had paid some attention to the combination of the silver and copper. He had found some cases in which the two metals seemed to form an alloy, while in others he had found nicely formed crystals of native copper combined with equally well-formed crystals of silver, and on testing these crystals he found both nearly equally pure.

Mr. Hyde Clarke inquired whether it was not the case in the long flues, of which mention had been made, that the deposit of metal was always found in the largest proportion nearest to the furnace, and less towards the further portions of the flue. There was a gentleman present (Mr. John Phillips) who was able to give them some information as to the mining operations in Spain.

Mr. J. A. Phillips said with regard to the deposits in the flues of furnaces, he was not practically acquainted with the working of all the metals, but with reference to those with which he was specially acquainted, he could say that the largest deposits were in the immediate vicinity of the furnace; and in proportion to the distance from the furnace the amount of the deposit decreased. He had also observed that in certain ores—particularly those of silver—the metal was carried off by mechanical action. An old pupil of his engaged in works in Spain had informed him that he invariably found that the deposit of silver was richer near the furnace than elsewhere.

Mr. Hyde Clarke presumed that the stuff at the further end of the flue was not worth taking out.

Mr. J. A. Phillips remarked that in the works in Spain, and elsewhere, where silver ores were treated, the deposit, even at the further end of the flues, contained a sufficient amount of silver to render its collection a matter of importance.

Mr. John Phillips was largely interested in the smelting of lead and silver. The important question now was as to the loss of silver sustained in the operation of calcining the ores. In the works in Spain with which he had been connected, the poorer ores, which only yielded about 4 ounces of silver per 100lbs. of ore, were calcined in what was known as Brunton's Calciner, which answered well for ores of this description, but with ores of the richer class the process of calcining by manual labour was found to answer best, because the charge was more carefully stirred up, and there was consequently less loss through the ore being carried off by the draught. He was not competent to enter into the chemical part of the subject, but he had no doubt that with careful manipulation the loss might be much diminished. Reverting to the subject of lead smelting, he was glad to hear Mr. Phillips state the result of his observations as to the saving of lead in the flues in the shape of fumes, because it was a matter of great importance. There were some works in Spain, where the loss of lead in the fumes was very great. He particularly alluded to the Linares works, where the Castillian furnaces were employed, and the loss was considerable until they adopted the plan of the long flue. When this was done the saving during the first month paid a large portion of the expense of building the flue. Then again a saving in the length of the flue might be made by the use of condensers; and some improvements had been made in the forms of these condensers. One form had been mentioned as having been recently introduced, in which there was a series of falls of water so arranged as to cool the gases without interfering with the draft of the furnace. In the use of these condensers it was most important to take care that the draft was not interfered with. If the draft was kept perfect they were of great value, and saved the cost of erecting long flues.

The Chairman said there were one or two points to which it was important that their attention should be called before this discussion closed. In the first place, branching from the subject, although associated with it, there was one important fact connected with lead. In Durham and Northumberland—taking the year 1857—they had 17,000 tons of lead produced, which gave 74,000 ounces of silver; whilst in Cumberland they found that, with a produce of only 4,700 tons of lead they had 43,500 ounces of silver. Going on to Yorkshire, they found that 7,875 tons of lead were produced, and yet they only obtained from that lead 445 ounces of silver. The remarkable point was, that going southward they found, as they got into Flintshire, with a produce of 2,280 tons of lead, they had 13,300 oz. of silver. With 5,509 tons of lead produced in Cardiganshire, they had 35,000 ozs. of silver. Going farther southward into Cornwall, with 6,000 tons of lead produced in 1857, they had 224,277 ozs. of silver; and in Devonshire, with 1,535 tons of lead produced, they had 50,200 ozs. of silver. There was no question but that there was some law regulating this, and it was a subject which called for inquiry. Again they had the important lead districts of Derbyshire, producing 6,000 tons of lead, from which it was stated, he believed with some degree of truth, that no silver whatever was obtained. He said, with some *degree* of truth; because the white lead manufacturers, obtaining the material from the Derbyshire smelters, had by the use of Pattinson's process, obtained silver from that lead, although it was not obtained by the Derbyshire smelters themselves. Mr. Phillips had mentioned the extraordinary case of "gossans," in connection with a mine in Cornwall, containing a large quantity of silver. This had been further exemplified in Cambourne, in Cornwall, where the fissures, in some cases at right angles to the main lode, and in others parallel to it, were found to contain an enormous quantity of silver existing as a chloride of silver mixed with the oxide of iron. Whilst waiting at the Cambourne station one day, he saw two tons of that material sent away, which was said to be worth £3,000, from the silver it contained. Mr. Phillips had also mentioned the

importance of looking for nickel and cobalt. There was every reason to believe that Cornwall contained large quantities of cobalt, which was now thrown away. This metal having been found in large quantities in the sandstone formation of Alderley Edge, some 50 years ago, a gentleman of Liverpool established works at that place for the preparation of smalt, but the excise came down upon him for the glass duty, and he was surcharged to an extent that ruined him; works, however, were being again established in that place. Cobalt also existed to a great extent in Cumberland, although our principal supply was obtained from the German, Norwegian and Swedish mines. The chairman further mentioned a curious fact, connected with the mines of the Duke of Devonshire. At Grassington, the lead was found only in the bands of limestone, and none whatever existed in the shale, whilst at a distance of ten miles off, at Cononley, the lead was found entirely in the shale, and none in the limestone. The cause of this he was not in a position to explain; but it was important that a better series of observations should be made and recorded. He fully agreed with what had been said by Professor Tennant as to the want of better education of a practical nature amongst the mining community, and those connected with mineralogical pursuits. He was sure they were losing a large amount of valuable products, from the want of proper knowledge upon the subject. As an example, he might mention that they were producing large quantities of sulphur from the iron pyrites of Wicklow, which was conveyed to St. Helen's to be manufactured into sulphuric acid, and the material remaining from that manufacture which was formerly thrown away, was now disposed of to another house, and being roasted with common salt, copper was produced as a muriate and precipitated by iron, and a chloride of silver was likewise produced, which, being dissolved out by a strong brine, was afterwards precipitated by zinc. The silver cake was sent to the metropolis, and instead of fetching the usual price of 5s. per oz. it brought from 8s. to 10s. per oz., on account of the gold it contained. This showed what could be done with a proper knowledge of the subject. He had now to propose a vote of thanks to Mr. Phillips for the valuable paper he had brought before them on the present occasion.

A vote of thanks was then passed to Mr. Phillips.

The Secretary announced that on Wednesday evening next, the 4th May, a paper, "On Timber for Ship-building," by Mr. Leonard Wray, would be read.

Home Correspondence.

PRODUCTS OF THE COMBUSTION OF COAL GAS.

Sir,—In order that the subject of my last communication to you may not be misunderstood, I think it right to state again that I have never denied the presence of a small portion of sulphur compound in coal gas; but what I do state is that oil of vitriol cannot, under the ordinary method, be produced from its combustion.

Dr. Letheby, in his last communication, recommends a plan whereby I shall be able to obtain this, to me, unattainable compound, viz., oil of vitriol; now the plan here suggested is the one I have used with others on a large scale five years' since, but without success; and it is very curious that this identical plan, now suggested by Dr. Letheby as his own, for proving the *formation* of oil of vitriol, is recorded in the third volume of the *Journal of Gas Lighting*, Sept. 1854, page 528, in a valuable paper by Mr. Lewis Thompson, as a means of proving that oil of vitriol is *not formed* by the combustion of coal gas. Now it is rather singular that Dr. Letheby has never seen this paper, especially as he has on former occasions quoted so liberally from the *Journal of Gas Lighting*. Mr. Lewis Thompson stands so high as a chemist, and especially in all matters connected with gas, that I can hardly think he can have been deceived, especially as his results have been so completely confirmed by other eminent chemists.

Dr. Letheby has not thought fit to notice the statement as to there being only the $\frac{1}{2000}$th part of ammonia in raw gas instead of over *one per cent.*, or the $\frac{1}{100}$th part, as stated by me; and in spite of his own daily analyses and the opinion of the highest authority in gas matters, he now (without acknowledging his mistake) tells you that the numbers are not his but Mr. Wright's. Is it not possible that some such mistake may have occurred throughout, and thus have made Dr. Letheby imagine he had got oil of vitriol when in fact it was something else?

I am, &c.,

F. J. EVANS.

April 19, 1859.

JAPAN VEGETABLE WAX.

Sir,—You did me the honour, some time back, to print in our *Journal*, Vol. IV., some rough suggestions sketched out by me at the suggestion of Sir William Hooker, to assist travellers in estimating the value of vegetable oils, tallows, and waxes, which they might come upon in out of the way parts of the world.

With the exception of liquid oils from the East Indies, and Shea butter from Africa, and palm kernel oil from the same place, there have been no very considerable importations of remarkable fatty matters until quite recently, when one has taken place on so large a scale, and from so new a country, as, in my opinion, to become of public interest.

About 700 tons of "Japan wax" have arrived in one ship, consigned to Messrs. Baring. This wax, as I am informed by Sir William Hooker, is obtained from the *Rhus Succedaneum*, which I believe to be a species of *Sumach*, and, therefore, a free grower. The wax in its properties appears to be half-way between wax and vegetable tallow, or Bassia butter.

The small parcels which have formerly reached this country have been used in our works in substitution for wax, in substitution for hard neutral fat, and, after conversion into the acid state, both for candles and night-lights. For the last, a mixture of Japan wax and fat of low melting-point makes a compact, soft, wax-like body.

I am, &c., GEO. F. WILSON.

Price's Patent Candle Company (Limited),
Belmont, Vauxhall, S., 25th April, 1859.

MEETINGS FOR THE ENSUING WEEK.

Mon. ......Royal Inst., 2. Annual Meeting.
London Inst., 7. Mr. John Ella, "On Chamber, Orchestral, and Ballet Music."
Entomological, 8.
Brit. Architects, 8. Anniversary.

Tues. ......Royal Inst., 3. Professor John Morris, "On Geological Science."
Civil Engineers', 8.
Pathological, 8.
Photographic, 8.

Wed. ......Society of Arts, 8. Mr. Leonard Wray, "On Timber for Ship building."
Geological, 8. 1.—Dr. Falconer, "On the Ossiferous *Grotta di Maccagnone*, near Palermo;" 2.—Professor Buckman, "On some fossil Saurian Eggs in the Great Oolite of Cirencester; 3.—Baron A. de Zigno, "On the Jurassic Flora;" 4.—Professor Phillips, "On some Sections south of Oxford."

Thurs .....Royal Inst., 3. Mr. Austen H. Layard, "On the Seven Periods of Art."
Royal Soc. Club, 6.
London Inst., 7. Mr. J. W. Hastings, "On Commercial Law, in connection with the Travers Testimonial Fund."
Antiquaries, 8.
Linnæan, 8. 1.—Dr. Hicks, "On Certain Organs in the Wings of Insects;" 2.—Dr. Seemann, "On the genera *Camellia* and *Thea*.
Chemical, 8. 2. Mr. S. C. Wood, "On Bases produced by nitrous substitution." 2. Mr. Blockey, "On the Manufacture of Sulphate of Copper."
Artists and Amateurs, 8.
Royal, 8½.

FRI. ......Archæological, 4.
Royal Inst., 8. Dr. Druitt, "On Houses in Relation to Health."
SAT.........Royal Inst., 3. Mr. J. P. Lacaita, "On Modern Italian Literature."
Royal Botanic, 3½.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

PAR. No.

Delivered on 1st, 2nd, and 4th April, 1859.

107. Galway Harbour—Copy of Report and Plan.
157. Greenwich Union—Return.
171. Poor Rates—Return.
50. Local Acts (48, Dungarvan Harbour Embankment)—Admiralty Report.
166. Boundaries of Boroughs—Return.
169. Proprietors (Scotland)—Return.
127. Exchequer Bills—Account.
172. Army (Purchase and Sale of Commissions)—Returns.
173. Army (Purchase and Sale of Commissions)—Copy of the data upon which Sir C. Trevelyan founded his statements.
97. Bill—Public Offices Extension (as amended by the Select Committee.)
Foreign Service Messengers—Papers.

Delivered on 5th April, 1859.

167. National Education (Ireland)—Returns.
176. Decimal Coinage—Return.

PATENT LAW AMENDMENT ACT.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, April* 15, 1859.]

682. J. Donat, 6, Rue Paradis Marais, Paris—Imp. in apparatus used with matches for obtaining instantaneous light.

Dated 19th March, 1859.

700. J. W. Hart, 60, St. Mary-Axe, London—An apparatus for the destruction of flies and other insects. (A com.)

Dated 22nd March, 1859.

722. W. Weild, Manchester—Imp. in machinery and arrangements for coating slips, sheets, rods, and bars of metal, and laths, rods, and boards of wood, and similar articles formed of other substances, with paints, varnishes, and other like preparations, and drying the same.
727. D. L. Banks, Kennington, Surrey—Imp. in suspension rail or road ways, and in machinery or apparatus connected therewith.
734. J. Macintosh, North Bank, Regent's-park, and Major G. Rhodes, Regent-street—Imp. in tents and such like coverings for shelter against the weather.

Dated 29th March, 1859.

778. T. Carr, Bebington, Chester—Imp. in machinery for disintegrating artificial manures and various other substances.
779. C. L. Roberts, Clerkenwell—Imp. in cigars.
781. J. W. Kelly, Ennis, Ireland—Imp. in gas burners.
782. E. de Caranza, 97, Rue des Petits Champs, Paris—A new system of gas lighting through new apparatuses and matters richer in gas than pit coal.
783. E. N. Normington, 19, High-street, Camden-town—The cleansing and re-manufacturing of old used dirty railway grease for the manufacturing of new railway grease, for the cleansing and re manufacturing of old used cotton waste, tow, or any textile fabrics, and for the purifying of oils or any fatty matter.
785. R. Searle, Woodford Wells, Essex—Imp. in apparatus used for transmitting signals by electricity for telegraphic purposes, and in the construction of telegraphic cables.
786. I. Spight, Glandford Briggs, Lincolnshire—Imp. in horse hoes.
787. T. Taylor, Vere-street, Middlesex—Improved means of giving increased strength to paper.
788. H. P. Burt, Charlotte-row, Mansion-house—Imp. in apparatus for preparing and preserving timber.
789. H. Moss, 62, Brill-row, Somers-town, and T. West, 5, Jewin-street—A machine for the cutting of leather for every purpose, and cutting cloths, linen, and other fabrics and materials.

Dated 30th March, 1859.

791. J. H. Linsey, 103, Cheapside—Certain imp. in binding or covering books.
793. W. V. Edwards, Swindon, Wiltshire—Imp. in the construction of ways and apparatus to facilitate the conveyance of mails, goods, and passengers.
794. G. T. Bousfield, Loughborough-park, Brixton—Imp. in preventing explosions in steam boilers. (A com.)
795. T. D. Shipman, Toronto, Canada West, N.A.—Imp. in apparatus for stamping and printing. (Partly a com.)
796. H. Jefferies, Birmingham—Imp. in castors for furniture.
797. J. Cartwright, Shrewsbury—An improved implement for crushing clods and pulverising the surface soil, also convertible into a press wheel roller.
798. C. P. Coles, R.N., Southsea—An apparatus for defending guns and gunners in ships of war, gun boats, and land batteries.
799. W. Gossage, Widnes, Lancashire—Imp. in the manufacture of certain alkaline silicates and in the production therefrom of liquor silicis or liquid flint.
800. A. V. Newton, 66, Chancery-lane—An improved governor for marine and other steam-engines. (A com.)
801. W. Smith, King-street, Smithfield, and E. Smith, Hamburgh—Imp. in means or apparatus for the purpose of regulating the flow or passage of fluids.

Dated 31st March, 1859.

802. J. Lacy and S. Simpson, and H. Smith, Travis Holme Mill, Walsden, near Todmorden, Lancashire—Certain imp. in machinery for preparing and spinning cotton and other fibrous materials.
803. C. Pickering, Tonbridge, Kent—Improved apparatus for brewing.
804. R. C. Ross, Glasgow—Improved apparatus for cultivating land.
805. T. Ivory, Edinburgh—Imp. in rotary engines.
807. A. Morton, Morton-place, Kilmarnock—Imp. in sextants or quadrants for nautical purposes, and which are also adapted to the measuring of altitudes or angular distances.
809. J. S. Bateson, 17, Bolton-street, Mayfair—Imp. in generating steam and in the apparatus employed therein.
810. F. Morton, James-street, Liverpool—Imp. in the construction of fences and the posts or pillars for the same, parts of which improvements are also applicable to the construction of gate posts or poles for telegraph purposes or for signal posts.
811. W. E. Newton, 66, Chancery lane—Imp. in mills for cleaning rice. (A com.)
812. A. V. Newton, 66, Chancery-lane—Imp. in the construction of steam boiler and other furnaces. (A com.)

Delivered on 1st April, 1859.

813. D. K. Clark, 11, Adam-street, Adelphi—Feed water heating apparatus.
815. I. Sigismund, Hull, Yorkshire—Certain imp. in the manufacture of artificial teeth, and in the apparatus connected therewith. (Partly a com.)
816. R. A. Brooman, 166, Fleet-street—Imp. in solidifying, pressing, and moulding, (A com.)
817. R. A. Brooman, 166, Fleet-street—A new preparation of indigo for dyeing. (A com.)
819. W. E. Newton, 66, Chancery-lane—An improved process of manufacturing sulphate of lead, carbonate of lead, nitrate of potash, and sulphate of soda. (A com.)
820. J. J. Davis, Percival-street, Clerkenwell—An improved pad, applicable for inking, damping, and other like purposes by hand.
821. W. Tod, Glasgow—Imp. in marine steam engines.
822. Y. M. Thomas, 2, Rue St. Appoline, Paris—An improved propeller for ships, vessels, boats, and water wheels.

Delivered on 2nd April, 1859.

823. J. Desmet-Séaut, 4, South-street, Finsbury—An improved gas burning and lighting apparatus.
825. J. Hall, Queen's-road Chelsea, and J. S. Sparkes, St. John's Wood—An improved application of machinery for the purpose of hoisting, lowering, pulling, or drawing weights.
827. S. Desborough, 24, Noble-street—Imp. in making up needles, steel pens, and other small articles for sale.
829. W. Mather, Manchester—An improved apparatus for catching and destroying flies and other insects.
831. M. Scott, 26, Parliament street, Westminster—Imp. in diving apparatus.
833. T. Richardson, and G. W. Jaffrey, Hartlepool, Durham—Imp. in the arrangements and construction of harbours of refuge, breakwaters, sea walls, or barriers, and other like structures.

Dated 4th April, 1859.

835. F. Potts and R. Brough, Birmingham—Certain imp. in the manufacture of calico printing rollers or cylinders, also in the machinery and apparatus for performing certain parts of the same, and which said apparatus are also applicable, separately or conjointly, to the manufacture of parallel and other metallic tubes, and the rolling of the metal for the same or other purposes.
837. C. F. Kirkman, Argyl street, Regent-street—Protecting telegraphic wires, and in using them for subterranean and submarine purposes.
839. W. Brown and C. N. May, Devizes—Imp. in haymaking machines.
841. W. E. Newton, 66, Chancery lane—An Imp. in ladies' hooped skirts. (A com.)
843. C. Russell, Stubbers, near Romford—An Imp. in the working of marine engines.
845. D. B. White, M.D., Newcastle-on-Tyne—Imp. in arranging ships' and other pumps.
847. D. Sowden, Bradford, Yorkshire—Imp. in jacquard machines employed for weaving figured goods or fabrics.

Dated 5th April, 1859.

849. G. Hazletine, 4, Southampton buildings, Holborn—Imp. in sewing machines.
851. L. Brierley, and H. Gearing, Birmingham—A new or improved method of ornamenting metallic bedsteads and other articles of metallic furniture.
853. G. F. Chantrell, and E. Dutch, Liverpool—Imp. in the apparatus for regulating the quantity of water to be used for the flushing of water-closets and other purposes.

855. J. Hetherington, Manchester, and T. Webb and J. Craig, Tutbury, Derby, Imp. in machinery or apparatus for spinning and doubling cotton and other fibrous materials.
857. N. Libotte, 33, Boulevart St. Martin, Paris—Improved safety apparatus to be applied to cages in the drawing of coals.

Dated 6th April, 1859.

859. T. P. Luff, Shepton Mallet, Somersetshire—Imp. in cheese vats.
861. J. A. H. Ballande, Paris—An imp. in the preparation of writing paper, and ink to be used thereon.
863. J. Rogers, 9, Queen-square, Bartholomew Close, and E. J. Tweed, 22, Castle street, Falcon-square—Imp. in coating conducting wires used for electric telegraphic purposes.

Invention with Complete Specification Filed.

860. I. Adams, Massachusetts. U. S.—An improved tubular chain cable guide for vessels' bulwarks. (A com.) 6th April, 1859.

[*From Gazette, April* 22, 1859.]

Dated 3rd March, 1859.

572. W. Mitcalfe, Coal Exchange, London—Imp. in discharging cargoes, and in raising and lowering bodies.

Dated 5th March, 1859.

588. R. Leake and M. Sykes, Barnsley, Yorkshire—Imp. in furnaces for consuming smoke and generating heat, parts of which improvements are applicable to furnaces generally.

Dated 9th March, 1859.

616. J. Cooke, Cheltenham—Imp. in apparatus for giving signals on railways and vessels, and other such like uses.

Dated 16th March, 1859.

662. H. Ambler, Halifax—Imp. in breech-loading ordnance, and in the means of producing part or parts thereof, which improvements are also applicable to what are called small arms.

Dated 17th March, 1859.

680. A. Mein, St. Rollox, Glasgow—Imp. in making glass bottles, and in the apparatus connected therewith.

Dated 23rd March, 1859.

740. B. Browne, 52, King William-street, London Bridge—A new method of working or operating switches and signals on railways by improved apparatus for that purpose. (A com.)

Dated 26th March, 1859.

762. William Redgrave, Tavistock-street, Middlesex—An improved pillow travelling cap.
764. S. Dreyfous, G. Richer, and E. Cormier, Paris—Imp. in preserving eggs.
792. J. W. Hadwen, Kebroyd Mills, Halifax—A new art or manufacture for converting certain kinds of silk waste into yarns or threads.

Dated 31st March, 1859.

806. T. Ivory, Edinburgh—Imp. in steam boilers and furnaces for the same.

Dated 2nd April, 1859.

824. A. Ripley, 21, Bridge street, Blackfriars, and J. Roberts, Nelson-square, Bermondsey—Imp. in machinery for striking or scraping leather and tanned or untanned hides.
826. A. Bessemer, Tavistock-terrace, Upper Holloway—Imp. in furnaces to be employed in the manufacture of iron and steel.
828. J. Skertchley, Ashby-de-la-Zouch, Leicestershire—Imp. in apparatus for regulating the pressure of gas.
830. A. Paget, Loughborough, Leicestershire—Imp. in the machinery or apparatus for the manufacture of looped fabrics, and in the manner of constructing the same.
822. M. Coupland, Haggerstone, Middlesex—Imp. in furnaces.

Dated 4th April, 1859.

836. J. Eccles, Blackburn—Imp. in machinery for making bricks, tiles, and other articles formed of plastic materials.
840. J. H. Burton, Enfield Lock, Middlesex—Imp. in the manufacture of barrels for small fire arms.
842. A. V. Newton, 66, Chancery-lane—An improved construction of retarding apparatus or break for railway carriages. (A com.)
844. M. A. Crooker, New York, U. S.—Imp. in paddle wheels for steamers.
846. E. Morewood, Endfield, Middlesex—Imp. in coating metals.

Dated 5th April, 1859.

850. E. Fairburn, Kirklees Mills, Mirfield—Imp. in machinery for carding wool and other fibrous substances.
854. B. Browne, 52, King William street, London Bridge—Imp. in propelling ships or other vessels through water. (A com.)
858. F. M. Crichton, Stoke Abbey, Stoke Bishop, Westbury-upon-Frym, Gloucestershire—Imp. in clocks or time keepers.

Dated 6th April, 1859.

862. W. Owen, Rotherham, Yorkshire—Imp. in the manufacture of railway wheels and tyres and in the apparatus employed therein. (Partly a com.)
864. J. Scoffern, 4, Barnard's-inn—Imp. in lubricating projectiles and cartridges.

Dated 7th April, 1859.

866. A. Chaplin, Glasgow, Lanark—Imp. in steam boilers.
868. R. Wardell, Stanwick, and H. Kearsley, Ripon, Yorkshire—Imp. in reaping machines.
870. John Lakin, junr., Hall End, near Tamworth—A new or improved agricultural drill.
872. J. Rawlings, Carlton Hill East—Improved construction of boot tree.

Dated 8th April, 1859.

874. W. H. Smith. Philadelphia, U. S.—Imp. in the construction of cartridges, and in the fire arms for using the same.
876. William Campion, Nottingham—Imp. in machinery for the manufacture of looped fabrics.
878. M. A. F. Mennons, 32, Rue de l'Echiquier, Paris—An improved articulated joint for water, gas, and steam pipes. (A com.)
880. N. A. Grumel, Paris—Imp. in dying cotton, wool, silk, flax, and other fibrous materials or fabrics.
882. W. Hooper, Mitcham, Surrey—Imp. in re-working or re-manufacturing compounds of india-rubber and sulphur.

Dated 9th April, 1859.

888. T. Barnett, Oldham, H. T. Sourbuts, and W. Loynd, Hyde, Imp. in steam engines.
890. J. Hawkins, Lisle-street, London, "Certain imp in the manufacture of stirrups, bits, spurs, buckles, and other such like articles connected with harness and saddlery.
892. R. J. Derham, 46, Redcliffe-street, Bristol—Imp. in cheese vats.
894. C. F. Vasserot, 45, Essex-street, Strand—A new motive power applicable to tanneries. (A com.)
896. H. F. Gardner, Boston, U.S.—Imp. in machinery for blocking or crimping the uppers of boots and shoes, and in treeing boots. (Partly a com.)

Dated 11th April, 1859.

904. A. Bower, Liverpool—Imp. in or applicable to the keels of navigable vessels.
906. R. A. Brooman, 166, Fleet-street—Imp. in candle moulds. (A com.)
908. W. H. Barlow, Great George-street, Westminster—Imp. in beams and girders.

Dated 12th April, 1859.

910. Lieut. W. Clark, R.N., Langhaugh, Galashiels, Scotland—An improved safety block to be used for lowering ships' boats, the same being applicable to other like or analogous purposes.
912. P. Aitchison, Sheffield—Imp. in taps.
914. E. T. Noualhier, Paris—An improved ventilator.
916. P. Hill, Manchester, and J. Moore, Salford—Imp. in weaving double pile fabrics.
918. M. Castay, Paris—Imp. in metallic bridges.
920. J. Ward, King's Norton, Worcestershire—An imp. or imps. in working fly presses used for raising metals, coining, and other like purposes.
922. S. Tatton, Leek, Staffordshire—Imp. in preparing and treating silk, and imps. in dyeing silk.

Dated 13th April, 1859.

924. W. A. Martin and J. Purdie, Woolwich—Imp. in fire bars.
928. W. Craft, 12, Cambridge-road, Hammersmith, and T. Wilson, Bradmore House, Chiswick—Imp. in the manufacture of pinafores and bibs for children.
632. J. L. Stevens, 1, Fish-street-hill, London—Imp. in the fire grates of locomotive, marine, and other furnaces.

Inventions with Complete Specification Filed.

935. J. Luis, 1B, Welbeck-street, Cavendish-square—A new cooling apparatus for liquids, especially beer. (A com.)—14th April, 1859.
988. A. W. Williamson, University College, London—Imp. in making extracts from liquorice root.—19th April, 1859.

WEEKLY LIST OF PATENTS SEALED.

[*From Gazette, April* 22, 1859.]

April 21st.

2389. J. Luis.
2391. A. P. A. Beau.
2392. J. Kinsey.
2395. G. Speight.
2408. B. Foster.
2410. J. Smith.
2412. P. Brunon.
1413. W. Kirrage.
2427. E. T. Hughes.
2438. M. A. F. Mennons.
2463. G. P. Evelyn.
2478. S. Davey.
2859. J. Webster.
2898. I. Ketchum.
282. J. Hosking and T. Cock.
348. T. Moss.
404. H. Gardner.
481. J. Grimond.

Patents on which the Stamp Duty of £50 has been paid.

[*From Gazette, April* 15, 1859.]

April 11th.

879. R. B. Lindsay.
963. C. Nickels.

April 12th.

876. R. S. Newall.
882. P. Robertson.
889. S. C. Lister.

[*From Gazette, April* 22, 1859.]

April 18th.

945. W. Crosley and G. Goldsmith.

April 19th.

994. C. Swift and J. J. Derham.

April 20th.

953. W. Maugham.
958. A. Symons and E. Burgess.

[*From Gazette, April* 26, 1859.]

April 21st.

1006. T. Heiffor.

April 23rd.

997. R. Lakin.
1003. C. A. Arnaud.
1058. I. Holden.
1097. G. J. Firmin.

Patent on which the Stamp Duty of £100 has been paid.

[*From Gazette, April* 22, 1859.]

April 19th, 1859.

452. J. Carnaby.